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(72) Inventor: **Ito, Hiroki**
Shinagawa-ku, Tokyo (JP)

(74) Representative: **Ayers, Martyn Lewis Stanley**
J.A. KEMP & CO.,
14 South Square,
Gray's Inn
London WC1R 5JJ (GB)

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(71) Applicant: **SONY CORPORATION**
Tokyo (JP)

(54) **Antenna element, adaptive antenna apparatus, and radio communication apparatus**

(57) An antenna element includes a substrate formed of a dielectric material having a specific inductive capacity exhibiting frequency distributing properties, a grounding conductor formed on one surface of the substrate, a plurality of radiating conductors formed on the

other surface of the substrate, and a plurality of feeder lines provided for passing through the substrate for connecting the grounding conductor to the radiating conductors. This antenna element is able to achieve equivalent gain for plural frequencies.

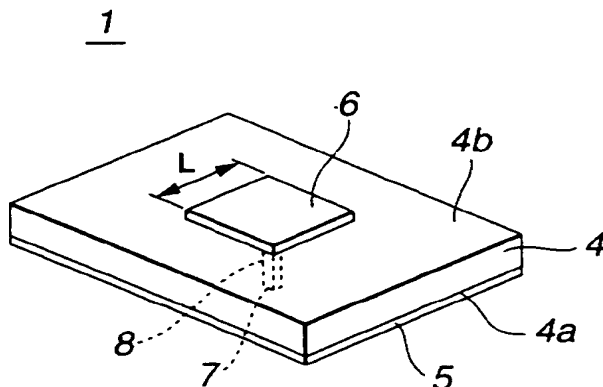


FIG.4

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Description

[0001] This invention relates to an antenna element for realizing equivalent gain for plural frequencies and to a radio apparatus applicable to plural radio communication systems having different frequency domains by having this antenna element mounted thereon.

[0002] In a radio communication system, such as a portable telephone system, which has come into surprisingly widespread use, not only call services but also transmission services for transmission of text information, such as E-mail. In the portable telephone system, downloading services for received melodies or character distributing services have met high acclamation. In the portable telephone system, a wide variety of measures are being taken to transmit the various forms of the information more speedily and at a higher quality. In near future, high quality moving picture information will also be transmitted in real-time.

[0003] As a new system to cope with high transmission speed in inland use, services conforming to IMT-2000 (International Mobile Telecommunication-2000) are scheduled to be started in the field of the portable telephone system. In this system, services can be furnished for the time being at a rate of 384 kbits/sec, against 64 kbits/sec of the pre-existing system, as a result of allocation of a new frequency band (2 GHz band). In the portable telephone system, a need exists for an equipment that enables various information signals to be received in this new frequency band.

[0004] In each radio communication system, the frequency band is prescribed, such that the limited frequency range needs to be exploited efficiently. The radio communication system needs to be designed so that an equipment exploiting the system will receive only the desired electrical waves while not receiving other electrical waves which prove to be interference, in order to permit the system to be exploited efficiently. In the radio communication system, an adaptive array antenna 100, shown in Figs. 1 to 3, is mounted on the equipment exploiting the system.

[0005] Referring to Fig. 1, the adaptive array antenna 100 includes plural antenna element 101, plural reception circuit units 102 for demodulating high harmonics received by the respective antenna element 101, and a parallel signal processing circuit unit 103 for optimizing the signals optimized by the reception circuit units 102. The adaptive array antenna 100 is adapted for simultaneously receiving high frequency signals oncoming from different directions by the antenna element 101 and for interrupting high frequency interference signals.

[0006] The respective reception circuit units 102 down-convert the high frequency signals received by the respective antenna element 101 to demodulate the received signals to bit signals. The parallel signal processing circuit unit 103 optimally synthesizes bit signals supplied from the reception circuit units 102. The adaptive array antenna 100 synthesizes bit signals in the manner of cancelling the information other than the information needed in the parallel signal processing circuit unit 103, and the noise, to operate as if the unit 100 is oriented in alignment with the direction of electrical waves for which antenna directivity is required, while being null with respect to the direction of oncoming of interference electrical waves.

[0007] The adaptive array antenna 100 provides plural outputs from the parallel signal processing circuit unit 103, so that, if there are two or more information that are required, the respective information will be output separately. That is, the adaptive array antenna 100 has characteristics such that it operates with plural directivities in meeting with the number of the required information. The adaptive array antenna 100 features enabling reception of plural information employing the same frequency band possibly present in the same space without crosstalk to achieve effective utilization of the frequency band.

[0008] The antenna element 101 includes, as shown in Figs. 2 and 3, a rectangular dielectric substrate 104 of e.g., Teflon (trade name of a product manufactured by DuPont de Nemur), a grounding conductor 105 provided on a first major surface 104a of the dielectric substrate 104, plural radiating conductors 106 bonded to a second major surface 104b of the dielectric substrate 104 and a feeder line 107 interconnecting the grounding conductor 105 and the radiating conductors 106. The dielectric substrate 104 has a specific inductive capacity ϵ_0 and includes plural feeder guide holes 108 passing through the first major surface 104a and the second major surface 104b, as shown in Fig. 3.

[0009] The grounding conductor 105 is a metallic plate of, for example, copper or brass, bonded to the first major surface 104a of the dielectric substrate 104. On the bottom surface of the grounding conductor 105 are arranged the reception circuit units 102. The radiating conductors 106 are bonded to the second major surface 104b of the dielectric substrate 104 kept parallel to the grounding conductor 105. The radiating conductors 106 are formed e.g., by chips of metal, such as copper or brass, each being of a square shape with each side being L in length. The length L of each side of the radiating conductor 106 is $\lambda/2$, where λ is the wavelength of the wave transmitted/received. The length L of the radiating conductor 106 is also set by

$$2L = c / (f_0 \times \sqrt{\epsilon_0})$$

where f_0 is the transmission frequency and c is the light velocity.

[0010] The feeder line 107 is a coaxial cable passed through the feeder guide hole 108 to interconnect the radiating

conductors 106 and the associated reception circuit units 102. Although not shown in detail, the feeder line 107 has its shell conductor and a core line connected to the grounding conductor 105 and to the radiating conductors 106, respectively.

[0011] In the above-mentioned adapter array antenna 100, high frequency signals 109 (109a, 109b, 109c) of the same frequency band, transmitted from different directions, are received by respective antenna element 101, as shown in Fig.3. In the adapter array antenna 100, the high frequency signals 109 are down-converted in the respective reception circuit units 102 associated with the antenna element 101 for demodulation to bit signals. As shown in Fig.1, the adapter array antenna 100 synthesizes the bit signals supplied from the respective reception circuit units 102 in the parallel signal processing circuit unit 103 such as to cancel the information other than the information needed in the parallel signal processing circuit unit 103 and noise to output the resulting signal.

[0012] In the radio communication system, plural systems employing different frequency bands have come to be furnished, as described above, such that equipment to be used in the system are required to cope with these systems. If the equipment is to be usable in common by the respective radio communication systems, plural antennas adapted to the respective systems are needed, thus being increased in size and cost.

[0013] In consideration that the portable telephone system has become surprisingly widespread on account of the small size and weight and inexpensiveness of the equipment, it is not possible to permit the portable telephone set to be bulky in size and costly with the introduction of new portable telephone system as described above. So, the new portable telephone system has an inconvenience that a portable telephone set furnished is not compatible with the conventional portable telephone set.

[0014] The conventional adaptive array antenna controls the directivity in the same frequency band to enable effective frequency utilization. If this adaptive array antenna is to be applied to plural systems having different frequency bands, plural antenna adapted to the specifications of the respective systems need to be used, as in other types of the antenna.

[0015] It is therefore an object of the present invention to provide an antenna and a radio apparatus which, in view of the above-described characteristics of the adaptive array antenna, the necessary information can be positively received in plural frequency bands to achieve effective frequency utilization.

[0016] In one aspect, the present invention provides a antenna element including a substrate formed of a dielectric material having a specific inductive capacity exhibiting frequency distributing properties, a grounding conductor formed on one surface of the substrate, a plurality of radiating conductors formed on the other surface of the substrate and a plurality of feeder lines provided for passing through the substrate for connecting the grounding conductor to the radiating conductors.

[0017] With the antenna element of the present invention, in which the substrate is formed of a dielectric material having frequency distribution characteristics, an equivalent gain may be achieved for plural frequencies.

[0018] In another aspect, the present invention provides a an adaptive antenna apparatus including a substrate formed of a dielectric material having a specific inductive capacity exhibiting frequency distributing properties, a grounding conductor formed on one surface of the substrate, a plurality of radiating conductors formed on the other surface of the substrate, a plurality of feeder lines provided for passing through the substrate for connecting the grounding conductor to the radiating conductors, a frequency distributing circuit fed with a reception signal of a plurality of frequency bands from the radiating conductors over the feeder line for outputting signals of the frequency bands in the reception signal in separate frequency bands, a plurality of demodulation circuits for demodulating the signals of the respective frequency bands from the frequency distributing circuit, and a signal synthesis circuit for synthesizing demodulated signals from the demodulating circuits according to the separate frequency bands.

[0019] With the adaptive antenna apparatus of the present invention, plural information transmitted from plural systems with different frequency bands can be received without crosstalk by a sole antenna device so that it is possible to reduce the size of the device.

[0020] The invention will be more clearly understood from the following description, given by way of example only, with reference to the accompanying drawings, in which:

Fig.1 is a schematic view showing a conventional adaptive array antenna.

Fig.2 is a perspective view showing a flat antenna used as an antenna element in the adaptive array antenna shown in Fig.1

Fig.3 is a schematic view showing a structure of a reception unit of the adaptive array antenna shown in Fig.1.

Fig.4 is a perspective view showing a flat antenna embodying the present invention.

Fig.5 is a graph showing the specific inductive capacity of a dielectric substrate used in the flat antenna of Fig.4.

Fig.6 is a schematic view showing a structure of a reception unit of an adaptive array antenna employing the flat antenna as an antenna element.

Fig.7 is a schematic view showing a structure of the adaptive array antenna.

Fig.8 is a schematic view showing a structure of a radio apparatus having the adaptive array antenna.

[0021] Referring to the drawings, preferred embodiments of the present invention will be explained in detail. A plurality of flat antennas 1, one of which is shown in Fig.4, are arranged in adjacency to one another, as shown in Fig.6 and 7 to make up an antenna element. An adaptive array antenna 2 is provided in a radio apparatus 3 shown in Fig.8, and constitutes a transmission/reception unit for receiving high frequency signals of different frequency bands transmitted from different directions and for transmitting high frequency signals of different frequency bands.

[0022] The flat antenna 1 has a basic structure similar to that of the conventional flat antenna and includes a rectangular dielectric substrate 4, a grounding conductor 5 provided on a first major surface 4a of the dielectric substrate 4, and a plurality of radiating conductors 6, respectively bonded to a second major surface 4b of the dielectric substrate 4, as shown in Fig.4. In the flat antenna 1, a feeder line 7, made up of a coaxial cable, is passed through a feeder guide hole 8 formed in the dielectric substrate 4 so that the respective radiating conductors 6 are connected by the feeder line 7 to the grounding conductor 5. The feeder line 7 has its shell conductor and a core line connected to the grounding conductor 5 and to the radiating conductors 6, respectively.

[0023] The grounding conductor 5 is formed of metal, for example, brass, and is bonded to the first major surface 4a of the dielectric substrate 4, as described above. The radiating conductors 6 are bonded to the second major surface 4b of the dielectric substrate 4 in a state of being parallel to the grounding conductor 5. The radiating conductors 6 are formed by chips of metal, such as brass, and are each formed to substantially a square shape each side of which has a length L. Also, the radiating conductors 6 are each sized so that its side has a length of $\lambda/2$, where λ is the wavelength of the wave transmitted/received.

[0024] The dielectric substrate 4 is molded from a dielectric material, the specific inductive capacity of which exhibits frequency distribution characteristics. The frequency response of the dielectric substrate 4 is such that the specific inductive capacity ϵ_1 to ϵ_n with respect to the length L of the side of the radiating conductor 6 and the frequencies f_1 to f_n are decreased gradually with the increasing frequency, as shown in Fig. 5. The dielectric substrate 4 is so designed that, by the specific inductive capacity ϵ_1 to ϵ_n having characteristics such as

$$2L = c / (f_1 \times \sqrt{\epsilon_1}) = c / (f_2 \times \sqrt{\epsilon_2}) = c / (f_3 \times \sqrt{\epsilon_3}) \dots = c / (f_n \times \sqrt{\epsilon_n})$$

it is possible for the dielectric substrate 4 to produce an output of the same wavelength for plural reception frequencies f_1 to f_n .

[0025] The dielectric substrate 4 may be molded from a hexagonal ferrite material having the composition of



or



where Me_1 is a tetravalent metallic ion, such as Ti, Zr or Sn ions, and Me_2 is a bivalent metallic ion, such as Co, Mn, Zn, Cu, Mg or Ni ions.

[0026] The adaptive array antenna 2, having the above-described flat antennal as an antenna element, is able to receive e.g., the first frequency range f_1 , a second frequency range f_2 and a third frequency range f_3 simultaneously. The adaptive array antenna 2 includes an array of flat antennas 10 (10a to 10n) comprised of an array of plural radiating conductors 6 (6a to 6n) on the first major surface 4a of the dielectric substrate 4, as shown in Fig.6.

[0027] The adaptive array antenna 2 includes a plurality of frequency distribution circuits 11 (11a to 11n) associated with the flat antennas 10, as shown in Fig.7. Each frequency distribution circuit 11 is connected to each flat antenna 10 via feeder line 7 (7a to 7n), as shown in Fig.6. Each frequency distribution circuit 11 distributes the high frequency signals, received by the flat antenna 10, into first to third frequency bands f_1 to f_3 .

[0028] The adaptive array antenna 2 includes plural reception circuit units 12 (12a to 12n) in association with the frequency distribution circuits 11, as shown in Figs.6 and 7. Each reception circuit unit 12 has three elementary reception circuit units 13, that is a first elementary reception circuit unit 13a1, a second elementary reception circuit unit 13a2 and a third elementary reception circuit unit 13a3, in association with high frequency signals of first to third frequency bands f_1 to f_3 , as shown in Fig.7. Each reception circuit unit 12 down-converts the high frequency signals of the first to third frequency bands f_1 to f_3 , distributed by each frequency distribution circuit 11, into baseband signals, for demodulation to bit signals.

[0029] Referring to Fig.7, the adaptive array antenna 2 includes three parallel signal processors 14 (first to third parallel signal processors 14a to 14c) fed from the elementary reception circuit units 13 of the reception circuit unit 12

with bit signals of the first to third frequency bands f1 to f3. Each parallel signal processor 14 optimally synthesizes bit signals for each of the first to third frequency bands f1 to f3. Each parallel signal processor 14 operates as if they are directed to electrical waves in need of antenna directivity and also as if they are null in the oncoming direction of interference signals, by synthesizing the bit signals for respective frequency bands such as to cancel the information other than the necessary information and the noise. Each parallel signal processors 14 outputs the optimized bit signals to system units 15 (first to third system units 15a to 15c) associated with the first to third frequency bands f1 to f3, respectively.

[0030] Referring to Fig.6, the adaptive array antenna 2 receives plural first high frequency signals 16 (16a to 16c indicated by solid lines in Fig.6), transmitted from different directions by the radio communication system employing the first frequency band f1, by an array of the flat antennas 10. The adaptive array antenna 2 receives plural second high frequency signals 17 (17a to 17c indicated by dotted lines in Fig.6), transmitted from different directions by the radio communication system employing the first frequency band f2, by an array of the flat antennas 10. Also, the adaptive array antenna 2 receives plural third high frequency signals 18 (18a to 18c indicated by chain-dotted lines in Fig.6), transmitted from different directions by the radio communication system employing the first frequency band f3, by an array of the flat antennas 10.

[0031] The adaptive array antenna 2, in which each flat antenna 10 includes a dielectric substrate 4 having specific inductive capacity exhibiting frequency distribution characteristics, receives the high frequency signals of the same wavelength for the first to third high frequency signals. The adaptive array antenna 2 distributes the first to third high frequency signals 18, received by the respective flat antennas 10, by the frequency distribution circuits 11 to the elementary reception circuit unit 13 of the reception circuit unit 12, for each of the first to third frequency bands f1 to f3. The adaptive array antenna 2 demodulates the high frequency signals by the elementary reception circuit unit 13 into bit signals which then are output to the parallel signal processors 14.

[0032] The adaptive array antenna 2 demodulates the first high frequency signals 16a of the first frequency band f1, received by the flat antenna 10a so as to be distributed by the frequency distribution circuit 11a, into bit signals, in the first elementary reception circuit unit 13a1 of the reception circuit unit 12, to output the resulting bit signals to the first parallel signal processors 14a. The adaptive array antenna 2 demodulates the second high frequency signals 17a of the second frequency band f2, received by the flat antenna 10a so as to be distributed by the frequency distribution circuit 11a, into bit signals, in the second elementary reception circuit unit 13a2 of the reception circuit unit 12, to output the resulting bit signals to the second parallel signal processors 14b. The adaptive array antenna 2 also demodulates the third high frequency signals 18a of the third frequency band f3, received by the flat antenna 10a so as to be distributed by the frequency distribution circuit 11a, into bit signals, in the third elementary reception circuit unit 13a3 of the reception circuit unit 12, to output the resulting bit signals to the third parallel signal processors 14c.

[0033] The adaptive array antenna 2 demodulates the first high frequency signals 16n of the first frequency band f1, received by the flat antenna 10b so as to be distributed by the second frequency distribution circuit 11b, into bit signals, in the third elementary reception circuit unit 13b1 of the reception circuit unit 12, to output the resulting bit signals to the first parallel signal processors 14a. The adaptive array antenna 2 demodulates the first high frequency signals 16n of the first frequency band f1, received by the flat antenna 10n so as to be distributed by the nth frequency distribution circuit 11n, into bit signals, in the nth elementary reception circuit unit 13n1 of the reception circuit unit 12, to output the resulting bit signals to the first parallel signal processors 14a.

[0034] The adaptive array antenna 2 optimizes the first high frequency signals 16 of the first frequency band f1, transmitted from different directions and received by the flat antennas 10, in the first parallel signal processors 14a, through the aforementioned route, to output the optimized signals as reception information 19a to 19n to a first frequency band system 22a. The adaptive array antenna 2 optimizes the second high frequency signals 16 of the second frequency band f2, transmitted from different directions and received by the flat antennas 10, in the second parallel signal processors 14b, through the aforementioned route, to output the optimized signals as reception information 20a to 19n to a second frequency band system 22b. The adaptive array antenna 2 optimizes the third high frequency signals 18 of the third frequency band f3, transmitted from different directions and received by the flat antennas 10, in the third parallel signal processors 14c, through the aforementioned route, to output the optimized signals as reception information 21 a to 21n to a third frequency band system 22c.

[0035] Thus, even if the plural high frequency signals 16 to 18 of different frequency bands f1 to f3 are sent to the adaptive array antenna 2 from different directions, the adaptive array antenna 2 is able to receive these signals without crosstalk. So, the adaptive array antenna 2 is able to receive the information not only in the same frequency band but also in different frequency bands, with compatibility, thus enabling effective frequency utilization without increasing the size of the antenna unit.

[0036] The radio apparatus 3, carrying the above-described adaptive array antenna 2, as shown in Fig.8, can be used in a radio transmission system employing different frequency bands. The radio apparatus 3 receives the plural high frequency signals 16 to 18 of the different frequency bands f1 to f3, sent thereto by plural flat antennas 10 from different directions, without crosstalk, to perform optimum processing thereon in a reception processor 25. The recep-

tion processor 25 is made up of the aforementioned frequency distribution circuit 11, reception circuit unit 12 and the parallel signal processor 14.

[0037] In the radio apparatus 3, the reception information 19 to 21, optimized for each of the frequency bands f1 to f3, as described above, are output from the reception processor 25 to a frequency band system unit 26. The radio apparatus 3 performs control signal processing, in the frequency band system unit 26, of properly controlling an annexed application unit 27, such as display unit or memory, to output control signals 24a to 24c associated with the frequency bands f1 to f3, respectively. The radio apparatus 3 performs pre-set processing in each part of the application unit 27, based on the control signals 24a to 24c.

[0038] In the radio apparatus 3, the adaptive array antenna 2, frequency band system unit 26 or the application unit 27 is controlled by a control signal 29 output by a system controller 28. The system controller 28 controls the accommodation to the frequency bands f1 to f3 or to the communication system, signal processing or application control by a software program to output a control signal 29. In other words, the entire operation of the radio apparatus 3 is controlled by the software program.

[0039] In the above-described embodiment, the operation of receiving the first to third high frequency signals 16 to 18 based on the first to third frequency bands f1 to f3 has been explained. It is however to be noted, that the adaptive array antenna of the present invention can also be connected in use to a transmission section. Although the dielectric substrate 4 has its dielectric substrate 4 formed of hexagonal ferrite to impart frequency distribution properties, the dielectric substrate 4 may, of course, be formed of any other suitable materials,

[0040] Although the radiating conductors 6 are formed by square-shaped batch devices, formed by rectangular chips, the present invention is, of course, not limited to these devices. The radiating conductors 6 may also be formed by arranging linear elements in a lattice shape or by etching a metal foil bonded to the surface of the dielectric substrate 4 e.g., by etching.

Claims

1. An antenna element comprising:

a substrate formed of a dielectric material having a specific inductive capacity exhibiting frequency distributing properties;
a grounding conductor formed on one surface of said substrate;
a plurality of radiating conductors formed on the other surface of said substrate; and
a plurality of feeder lines provided for passing through said substrate for connecting said grounding conductor to said radiating conductors.

2. The antenna element according to claim 1 wherein each of said radiating conductors is of a square shape with each side thereof L being such that $L = \lambda/2$, where L is the length of each side of the square and λ is the wavelength of a reception or a transmission signal.

3. The antenna element according to claim 1 or 2 wherein said radiating conductors are arranged in an array.

4. An adaptive antenna apparatus comprising:

a substrate formed of a dielectric material having a specific inductive capacity exhibiting frequency distributing properties;
a grounding conductor formed on one surface of said substrate;
a plurality of radiating conductors formed on the other surface of said substrate;
a plurality of feeder lines provided for passing through said substrate for connecting said grounding conductor to said radiating conductors;
a frequency distributing circuit fed with a reception signal of a plurality of frequency bands from said radiating conductors over said feeder line for outputting signals of said frequency bands in said reception signal in separate frequency bands;
a plurality of demodulation circuits for demodulating the signals of the respective frequency bands from said frequency distributing circuit; and
a signal synthesis circuit for synthesizing demodulated signals from said demodulating circuits according to said separate frequency bands.

5. The adaptive antenna apparatus according to claim 4 wherein each of said radiating conductors is of a square

shape with each side thereof L being such that $L = \lambda/2$, where L is the length of each side of the square and λ is the wavelength of a reception or a transmission signal.

6. The adaptive antenna device according to claim 4 or 5 wherein said radiating conductors are arranged in an array.

7. A radio communication apparatus capable of communication in a plurality of communication systems, comprising:

a substrate formed of a dielectric material having a specific inductive capacity exhibiting frequency distributing properties;

a grounding conductor formed on one surface of said substrate;

a plurality of radiating conductors formed on the other surface of said substrate;

a plurality of feeder lines provided for passing through said substrate for connecting said grounding conductor to said radiating conductors;

a frequency distributing circuit fed with a reception signal of a plurality of frequency bands from said radiating conductors over said feeder line for outputting signals of said frequency bands in said reception signal in separate frequency bands;

a plurality of demodulation circuits for demodulating the signals of the respective frequency bands from said frequency distributing circuit;

a signal synthesis circuit for synthesizing demodulated signals from said demodulating circuits according to said separate frequency bands; and

a signal processing circuit fed with signals from said signal synthesis circuit synthesized for said respective frequencies, said signal processing circuit accommodating said plural communication systems.

8. The radio communication apparatus according to claim 7 wherein each of said radiating conductors is of a square shape with each side thereof L being such that $L = \lambda/2$, where L is the length of each side of the square and λ is the wavelength of a reception or a transmission signal.

9. The radio communication apparatus according to claim 7 or 8 wherein said radiating conductors are arranged in an array.

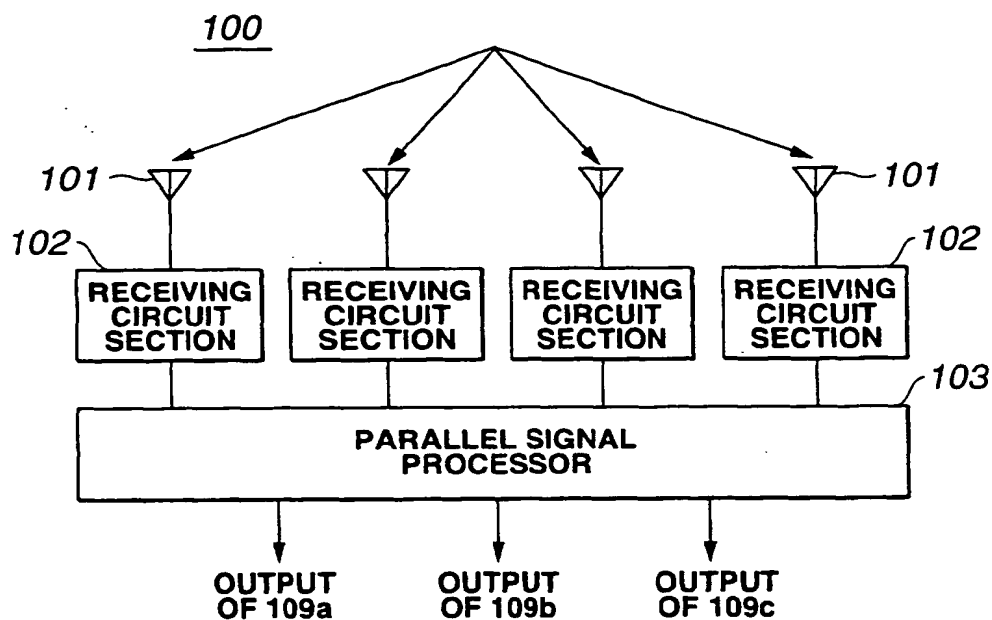


FIG.1

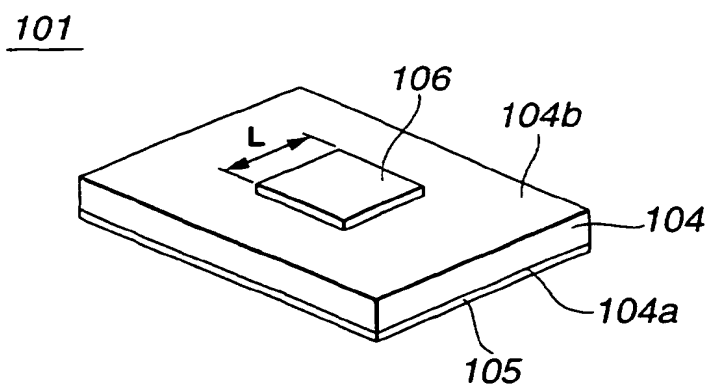


FIG.2

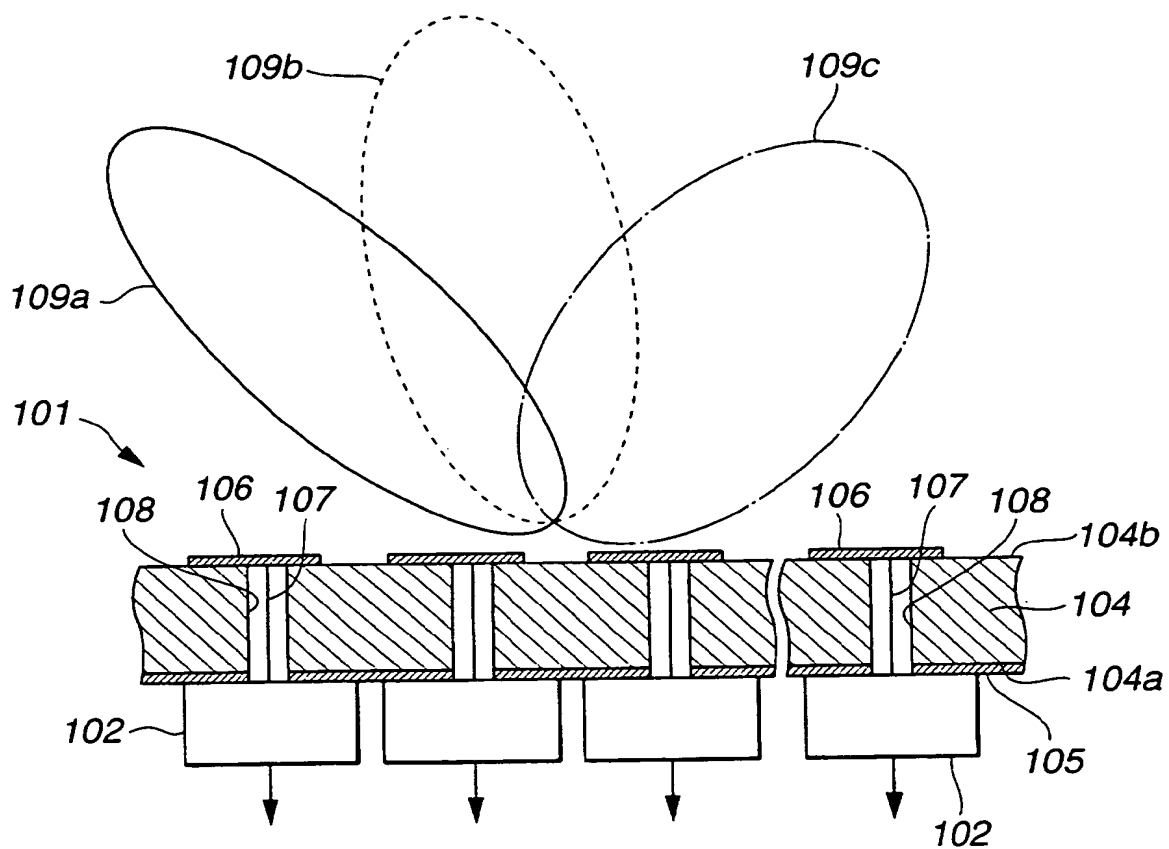


FIG.3

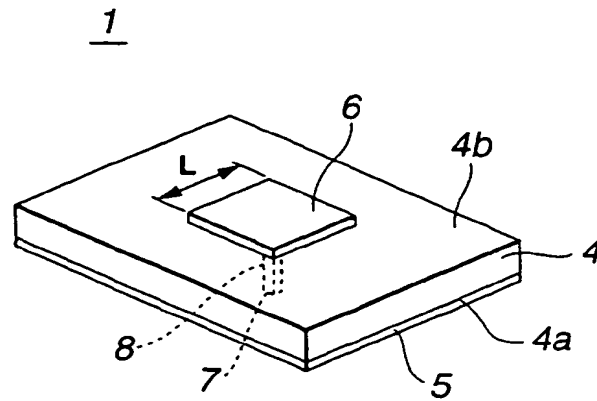


FIG.4

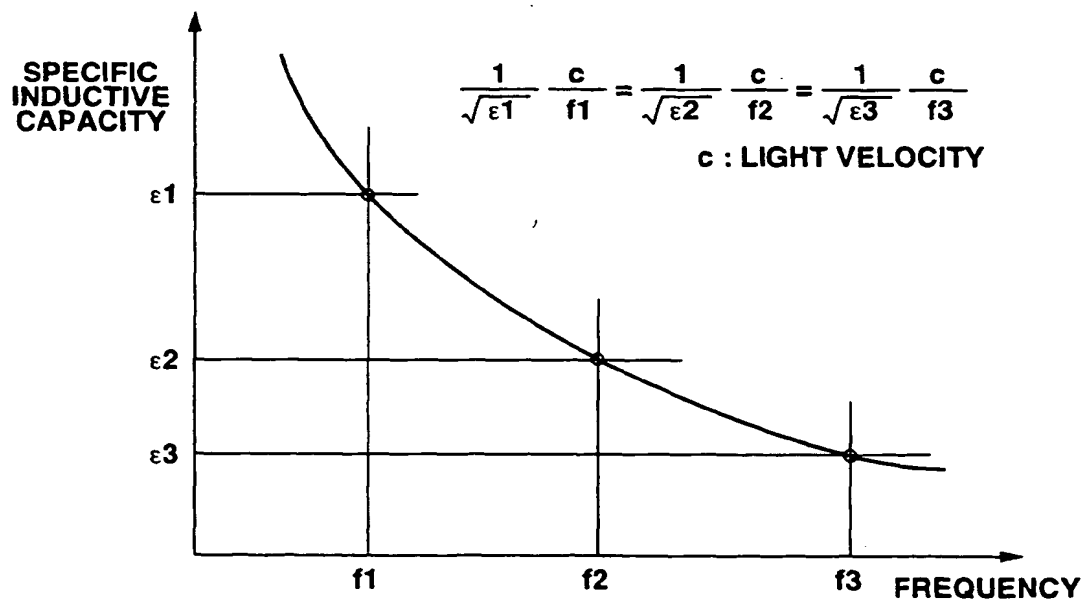


FIG.5

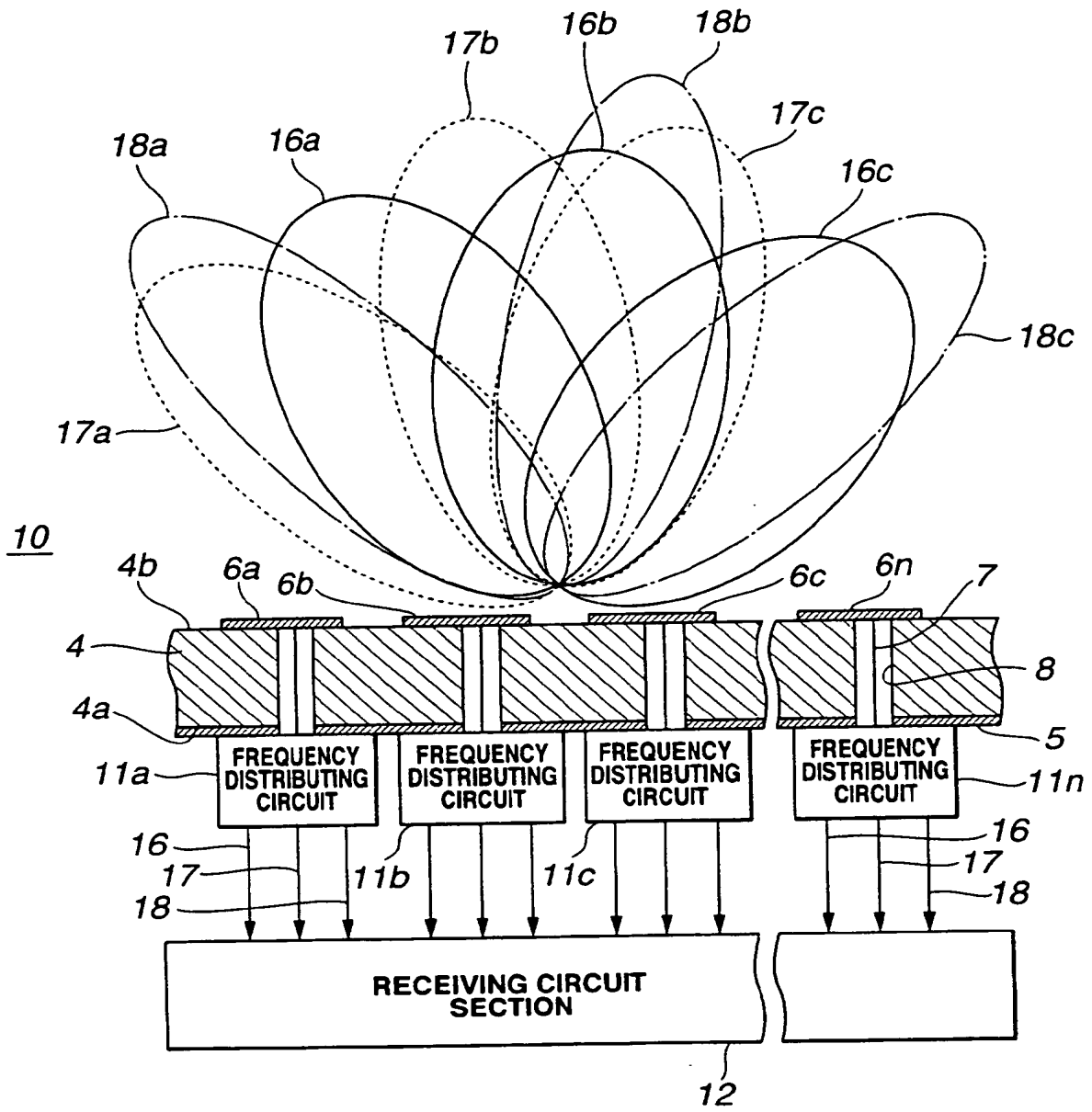


FIG.6

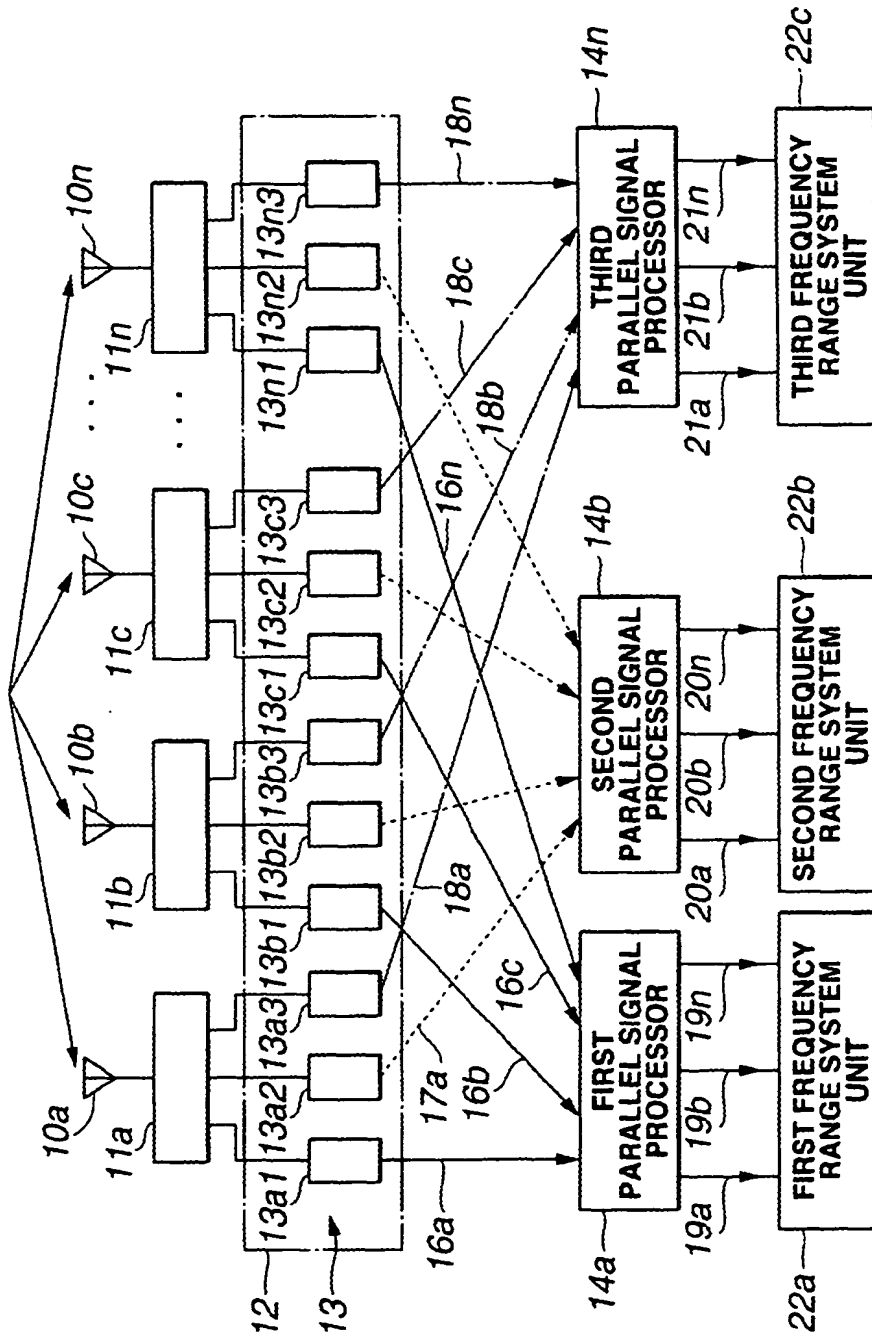


FIG.7

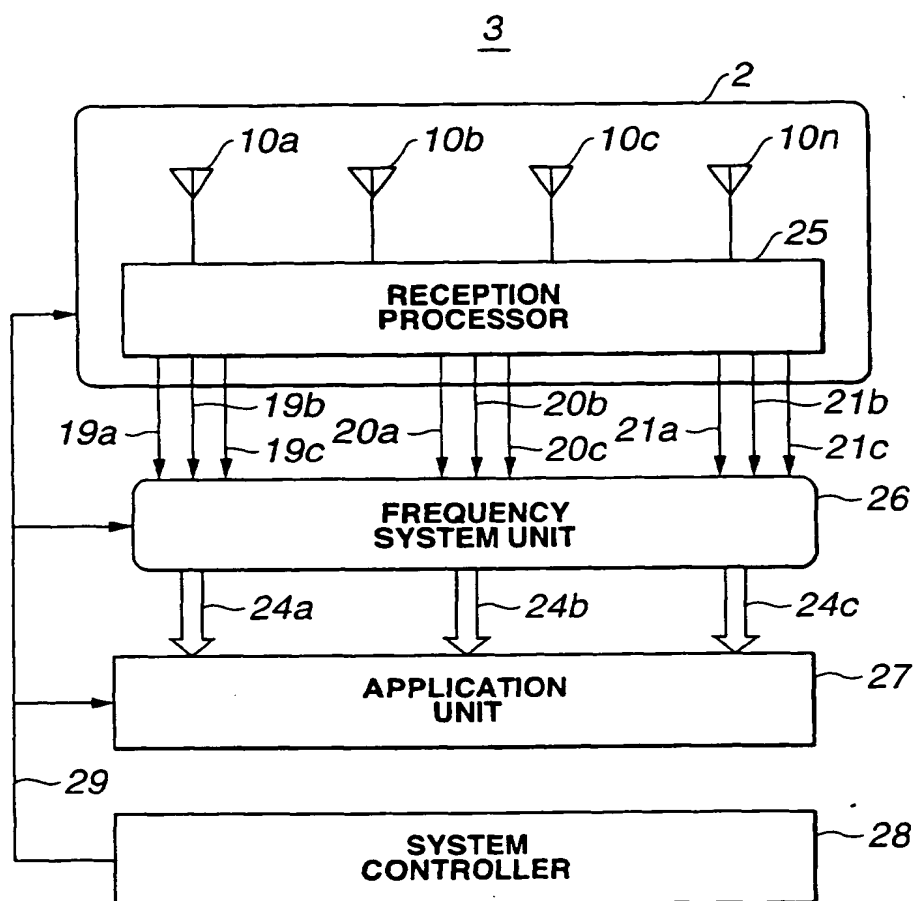
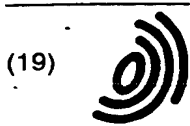


FIG.8



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(72) Inventor: **Ito, Hiroki**
Shinagawa-ku, Tokyo (JP)

(74) Representative: **Ayers, Martyn Lewis Stanley**
J.A. KEMP & CO.,
14 South Square,
Gray's Inn
London WC1R 5JJ (GB)

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(71) Applicant: **SONY CORPORATION**
Tokyo (JP)

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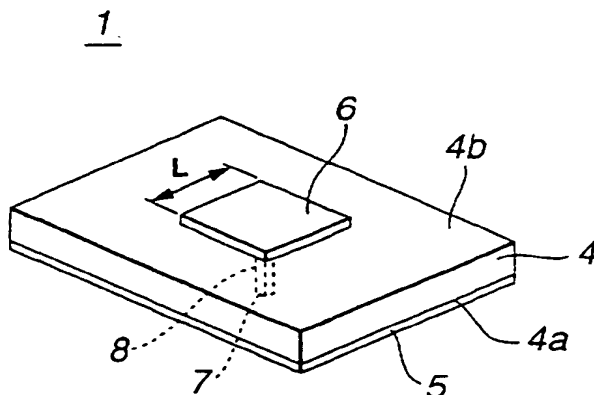


FIG.4



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 01 30 4948

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 497 168 A (THOMAS MICHAEL D ET AL) 5 March 1996 (1996-03-05) * column 1, paragraph 1; claims 1,2; figures 5,9 *	1-3	H01Q9/04 H01Q3/26 H01Q21/06 H01Q1/24
X	US 5 003 318 A (BERNEKING WILLIAM D ET AL) 26 March 1991 (1991-03-26) * column 4, line 4 - line 62; figures 1-10 * column 2, line 4 *	1-6	
X	EP 0 817 310 A (HUGHES AIRCRAFT CO) 7 January 1998 (1998-01-07) * column 2, line 44 - column 4, line 40; figures 1-5 *	1-3	
X	WO 93 09613 A (CALLING COMMUNICATIONS CORP) 13 May 1993 (1993-05-13) * page 11, line 11; figures 23-26,38,42 *	1-9	
A	WO 95 25409 A (ENDLINK INC) 21 September 1995 (1995-09-21) * the whole document *	1-9	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01Q
A	ABO EL ATA A M ET AL: "Dielectric and magnetic permeability behavior of BaCo ₂ -xNi _x Fe ₁₆ O ₂₇ W-type hexaferrites" JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS, ELSEVIER SCIENCE PUBLISHERS, AMSTERDAM, NL, vol. 204, no. 1-2, September 1999 (1999-09), pages 36-44, XP004180288 ISSN: 0304-8853 * the whole document *	1,4,7	
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 14 March 2003	Examiner Kaleve, A
CATEGORY OF CITED DOCUMENTS X: particularly relevant if taken alone Y: particularly relevant if combined with another document of the same category A: technological background O: non-written disclosure P: intermediate document		T: theory or principle underlying the invention E: earlier patent document, but published on, or after the filing date D: document cited in the application L: document cited for other reasons &: member of the same patent family, corresponding document	

EPO FORM 1503 03.02 (P04C01)



European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 01 30 4948

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
A	<p>ABO EL ATA A M ET AL: "Room temperature electric and dielectric properties of polycrystalline BaCo/sub 2x/Zn/sub x/Fe/sub 12-2x/O/sub 19/"</p> <p>JOURNAL OF MATERIALS SCIENCE LETTERS, 1 MARCH 1998, CHAPMAN & HALL, UK, vol. 17, no. 5, pages 409-413, XP009007841</p> <p>ISSN: 0261-8028</p> <p>* the whole document *</p> <p>-----</p>	1,4,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
MUNICH		14 March 2003	Kaleve, A
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone</p> <p>Y : particularly relevant if combined with another document of the same category</p> <p>A : technological background</p> <p>O : non-written disclosure</p> <p>P : intermediate document</p> <p>T : theory or principle underlying the invention</p> <p>E : earlier patent document, but published on, or after the filing date</p> <p>D : document cited in the application</p> <p>L : document cited for other reasons</p> <p>& : member of the same patent family, corresponding document</p>			

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**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 01 30 4948

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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14-03-2003

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5497168	A	05-03-1996	NONE	
US 5003318	A	26-03-1991	US 4827271 A	02-05-1989
EP 0817310	A	07-01-1998	US 5745079 A	28-04-1998
			AU 698570 B2	05-11-1998
			AU 2834397 A	15-01-1998
			CA 2208606 A1	28-12-1997
			EP 0817310 A2	07-01-1998
			JP 10150320 A	02-06-1998
WO 9309613	A	13-05-1993	AT 182729 T	15-08-1999
			AU 3054992 A	07-06-1993
			CA 2121587 A1	13-05-1993
			DE 69229678 D1	02-09-1999
			DE 69229678 T2	06-04-2000
			EP 0611500 A1	24-08-1994
			EP 0935349 A2	11-08-1999
			WO 9309613 A1	13-05-1993
			US 5736959 A	07-04-1998
			US 6157621 A	05-12-2000
WO 9525409	A	21-09-1995	AT 192276 T	15-05-2000
			AU 2117595 A	03-10-1995
			CA 2185711 A1	21-09-1995
			DE 69516512 D1	31-05-2000
			DE 69516512 T2	09-11-2000
			EP 0750827 A1	02-01-1997
			EP 0998156 A2	03-05-2000
			US 6052582 A	18-04-2000
			WO 9525409 A1	21-09-1995
			US 5771449 A	23-06-1998

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82